GREAT LAKES INDIAN FISH AND WILDLIFE COMMISSION

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• MEMBER TRIBES •

MICHIGAN	WISCONSIN		MINNESOTA
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Keweenaw Bay Community	Lac Courte Oreilles Band	St. Croix Chippewa	Mille Lacs Band
Lac Vieux Desert Band	Lac du Flambeau Band	Sokaogon Chippewa	

<u>Via Electronic Mail / Original by Mail</u> August 11, 2015

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Re: Comments on PolyMet mine site contaminant northward flowpath and groundwater model calibration.

NorthMet EIS Co-lead Agency Project Managers:

Following up on the web-meeting of July 22, emails of February 26, April 10 , April 20, letter of June 18 and emails of July 21 and July 29, we will clarify our concerns related to a northward flowpath and model calibration These comments are based on: 1) our letter of June 18th; 2) the materials provided in the Co-lead Agency draft memos on a northern flowpath and model calibration; 3) the webinar/meeting conducted July 22, 2015; 4) materials in the PFEIS of June 2015; and 5) further analysis. Since before 2008, GLIFWC staff have consistently raised concerns about the quality and validity of the groundwater characterization at the mine site. Most recently it has come to our attention that the mine site MODFLOW model was incorrectly bounded and calibrated and unlikely to provide the hydrologic characterization of the site that is needed in order to perform adequate project impact evaluations. It has also come to our attention that detailed (MODFLOW) and simplistic (MathCad) models predict that a northward contaminant flowpath is probable under likely closure conditions.

GLIFWC is acting in coordination with our member tribes, including the Fond du Lac Band, to review and contribute to the PolyMet EIS process. As you may know, GLIFWC is an organization exercising delegated authority from 11 federally recognized Ojibwe (or Chippewa) tribes in Wisconsin,

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Michigan and Minnesota.[1] Those tribes have reserved hunting, fishing and gathering rights in territories ceded in various treaties with the United States. GLIFWC's mission is to assist its member tribes in the conservation and management of natural resources and to protect habitats and ecosystems that support those resources. The proposed PolyMet mine is located within the territory ceded by the Treaty of 1854.

Mine-site MODFLOW model calibrated to conditions that did not exist in the 1980s, do not exist now and will not exist in the future:

The existing Northshore Peter-Mitchell (P-M) taconite mine pits on the north side of the PolyMet project area play a significant role in the groundwater hydrology of the project site. In the applicant's groundwater model of 2014 (and earlier versions), documented in the "Water Modeling Data Package Vol 1-Mine Site v13 DEC2014.pdf" (WMDPv13), those pits supply approximately 90% of the groundwater baseflow to the upper Partridge River (see GLIFWC email of 4/20/2015). It is not surprising that those taconite pits play a significant role in the local groundwater hydrology since they are positioned high in the local terrain, at times contain large volumes of water, and sit in relatively high conductivity bedrock (Biwabik Iron Formation or BIF and Virginia Formation). Because they play a dominant role in the local hydrology, it is critical that they be correctly incorporated into the project hydrologic modeling.

Unfortunately, the existing project MODFLOW model for the PolyMet mine site was calibrated using P-M taconite pit water levels that were 13 or more meters too high. The project model incorporates the P-M pits as constant-head-cell boundary conditions (Large Figure 7 of Attachment B of the WMDPv13, attached as Figure 1). The project model sets the P-M pit lakes as constant-head-cells approximately 5 meters above the level of the upper Partridge River, yet pit lakes during the period when flow data was collected (1979-88) were actually well below the elevation of the upper Partridge. Because of this error, the calibration model has the local direction of groundwater flow from the pits 180 degrees reversed from the actual conditions during the calibration period. The model predicts that during the calibration period water was flowing from the hydrologic high at the P-M pits to the hydrologic low at the upper Partridge River, when in fact, because the pits were partly to completely empty, water would have been flowing from the upper Partridge River to the P-M pits.

Attached is a figure that shows the predicted water tables and groundwater flow between the upper Partridge and the P-M pits when the P-M pits are set at different levels (attached as Figure 2). In red are the project model results used in recent and past project reports. In those models the P-M pits are assumed to be at their 1996 elevation of 493 meters. The 483 meter model (in purple) is the same as the project model except that the water levels in the P-M pits, that are adjacent to the upper Partridge, are set to 483 meters. An average pit water elevation of less than 480 meters appears to be the correct elevation for the calibration period of 1979-1988 (attached as Table 1). Calibration and use of the MODFLOW model with the P-M pits erroneously set to the unusually high conditions in 1996 (493 meters) is a problem for the following reasons:

- The baseflow used in formulating (calibrating) the PolyMet project MODFLOW mine site

1 GLIFWC member tribes are: in Wisconsin -- the Bad River Band of the Lake Superior Tribe of Chippewa Indians, Lac du Flambeau Band of Lake Superior Chippewa Indians, Lac Courte Oreilles Band of Lake Superior Chippewa Indians, St. Croix Chippewa Indians of Wisconsin, Sokaogon Chippewa Community of the Mole Lake Band, and Red Cliff Band of Lake Superior Chippewa Indians; in Minnesota -- Fond du Lac Chippewa Tribe, and Mille Lacs Band of Chippewa Indians; and in Michigan -- Bay Mills Indian Community, Keweenaw Bay Indian Community, and Lac Vieux Desert Band of Lake Superior Chippewa Indians.

model was calculated from flow conditions in the 10 years of 1979 through early 1988. During calibration, the MODFLOW model was adjusted until the baseflow it predicted matched the 0.51 cfs baseflow target at station SW003, where the Dunka Road crosses the Partridge River.

- The water level in the P-M pits used as boundary conditions when calibrating the project model was assumed to be 493 meters elevation, the water elevation in 1996. This level is much higher than any water levels that occurred during the period when flow was measured.

- The average water level in the P-M pits, when the baseflow at SW003 was estimated to be 0.51 cfs (i.e. in the 10 years of 1979 to early 1988), was actually more than 13 meters lower, at less than 480 meters.

As the diagram shows, with the pit water levels that occurred in November of 1986 (i.e. ~483 meters), the upper Partridge would have been losing water to the pits and would have had no baseflow. The water table would have sloped down northward from the Partridge River toward the P-M taconite pits. This is because the riverbed of the upper Partridge River is at 486-489 meters elevation, whereas the water levels in the adjacent P-M pits were at approximately 483 meters elevation in 1986. Average water levels in the P-M pits during the 10 years for which baseflow was calculated (1979-1988) were *even lower* than the 483 meter elevation found in 1986.

Water levels in the P-M Area003-East pit increased from an elevation of less than 478 meters in 1979 to 488 meters in the fall of 1987. During most of that period the Area003-East pit was empty, i.e. less than 478 meters elevation. In contrast the 1996 water level used for the Area003-East pit was 492.6 meters elevation. The P-M pit water levels were not vaguely "variable" as stated in the draft memo on calibration, but rather consistently well below the levels used in the Barr MODFLOW modeling. The 1996 water level used for the P-M pits as a boundary condition in the modeling was abnormally high. Such high levels did not occur in the 1980s, do not occur now and will not occur at closure.

The significance of this is that the MODFLOW model was calibrated (adjusted to fit reality) to average baseflow calculated for 1979-88, yet the P-M pit water levels used as boundary conditions in calibration were the unusually high levels that occurred in 1996, not those that occurred in 1979-88 or those that occur now. A fundamental requirement of model calibration is that the calibration targets (i.e. baseflows) and the model boundary conditions (i.e. the water levels in the taconite pits) must be from the same time period. The hydrologic system in 1996 was significantly different from the system in 1979-88 because the water levels in the taconite pits were so different. The result of this mis-match of boundary conditions and calibration targets is that the model is incorrectly calibrated and can not be expected to produce accurate predictions. The model gives the impression of generating reasonable results but is based on conditions that never existed at the same point in time. The 1996 boundary conditions in the form of P-M pit water levels did not occur in the 1980s, do not occur now and are not expected to occur in the future. Given the importance of the P-M pit water elevations as boundary conditions, this is a critical flaw.

Contrary to statements in the WMDP (v13) section on Model Technical Review Checklist, the MODFLOW model was not evaluated to sensitivity of some of the most significant boundary conditions, the Constant-head boundary conditions representing the P-M pits. If such evaluation had been done, it would have been obvious that the model was very sensitive to the levels specified at those pits. Our analysis suggest that approximately 90% of upper Partridge River baseflow comes from the P-M pits when the P-M are at their 1996 level and the shape of the watertable and bedrock potentiometric surface is highly dependent on the P-M pits boundary condition in the model.

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Sensitivity analysis as a substitute for correct model bounding and calibration:

It has been proposed that sensitivity analysis can substitute for understanding site hydrology. While sensitivity analysis on a properly bounded and calibrated model provides insights on the range of possible predictions, sensitivity analysis conducted on a grossly mis-configured model can not be depended upon. The closure period model, on which the sensitivity analysis was conducted, was configured with boundary condition in the form of P-M pit water levels at their 1996 levels, over 300 feet higher than the water levels actually expected at the time of PolyMet closure. Those P-M pits are close to the center of the model used for sensitivity analysis and, therefore, erroneous boundary conditions of this magnitude invalidate the results of the sensitivity analysis.

Northward Flow of Contaminants from PolyMet Pits and Category 1 Stockpile at Closure:

Northward flow in the bedrock aquifer:

The project mine site MODFLOW model distributed to cooperating agencies on January 5, 2015 was used by the applicant to predict that contaminants would flow from the mine site at closure to the south and south-east (for example: Large Figures 28 & 29 of the WMDPv13, attached as Figures 3 and 4). In those project model runs of closure conditions, the water levels in the P-M taconite pits were assumed to remain at the level found in 1996. At closure the P-M pits will not be at 1996 levels but over 300 feet lower. In fact those 1996 levels were atypical; they did not occur in the 1980s, do not occur now and will not occur at closure. A plot of water levels in the Area003-East P-M pit, the pit closest to the PolyMet east pit, shows how atypical the mid-1990s water levels were (attached as Figure 5). In the project predictive models of closure conditions, the adjacent taconite pits to the PolyMet project site were set to have a 1996 water elevation of 1616 feet or 493 meters. However, the P-M taconite pit water levels expected at P-M pit closure are 1300 feet or 396 meters. After reflooding of the P-M pits, the water levels in those pits will be maintained by an outfall in the north-east at 1500 feet or 457 meters (see figure from the Northshore Watershed Mitigation Plan of 2011, attached as Figure 6).

Given the large effect that the project groundwater MODFLOW model and ERM's MathCad cross-section model indicate the water in the taconite pits has on the local bedrock hydrology, one would expect that a large change in the elevation of the water in the taconite pits would have a significant impact on local hydrology and predictions of closure conditions. The close proximity of the P-M pits to the Partridge River and PolyMet mine features (attached Figure 7) suggests that the taconite mine pits would impact the hydrology of these features. In fact, runs of the project model indicate that the groundwater flow direction between the PolyMet project and the taconite pits would be reversed if the taconite pits had the correct P-M pit closure water elevation of 396 meters or even the very long-term level of 457 meters (attached as Figure 8). This initial modeling, conducted by GLIFWC, limited the amount of water that could be lost by the Partridge River to the aquifer because the Partridge can not be an infinite source of water. However, supplemental modeling such as that provided during the July 22nd meeting, (see email of July 21 "Materials for July 22nd modeling discussion, part 2", attached as Attachment A) had no such limitation, yet still showed a strong bedrock gradient toward the P-M taconite pits at closure. That supplemental modeling, without limiting leakage from the bottom of the Partridge River, showed a steep bedrock groundwater gradient from the PolyMet east pit to the P-M pits at closure water levels of 1300 ft (396 meters) and 1500 ft (457 meters) (attached as Figure 9). Additional MODFLOW modeling with recharge to the top of the model set at over 8 in/yr also showed northward flow from the PolyMet project at closure. Under this high recharge modeling scenario, a

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small mound does develop in the bedrock aquifer but not one large enough to prevent northward flow. Development of a groundwater mound is limited, not because of low recharge, but because of the low vertical conductivity of the surficial deposits and the strong pull of the low water levels in the P-M pits.

Northward flow of groundwater is in agreement with ERM's Mathcad model which shows bedrock water levels sloping steeply to the north given the water levels expected at closure of the P-M pits. According to ERM's MathCad analysis, only if a groundwater mound forms in the bedrock would flow to the north not occur (attached as Attachment B). Formation of such a substantial mound by movement of water downward from the 100 Mile Swamp is simply not possible given the hydrogeology defined by project documents (e.g. WMDPv13 Table 3-4, attached as Table 2).

The draft co-lead memo on a northward flowpath correctly states that:

> "for the case where downward leakage is negligible ..., the mound does not develop, there is no drainage divide, and the bedrock system would have continuous northward flow from the proposed NorthMet East Pit to the Northshore pits."

and

> "a key factor in the conceptual model is the amount of downward leakage from the surficial deposits into bedrock."

The memo goes on to state that at least 8 inches/year of leakage into the bedrock would be necessary to prevent northward flow. What has not been demonstrated is that the 8 inches per year of leakage into the bedrock is theoretically possible, given the low vertical conductivity of the overlying wetlands.

The result, from both the project MODFLOW model runs with the correct closure water elevations and ERM's MathCad model runs, indicate that water in bedrock will flow to the north from the PolyMet site at closure, unless a bedrock groundwater mound forms. <u>No feasible natural mechanism for such a mound has been articulated.</u> A bedrock groundwater mound at the level necessary to prevent northward flow, i.e. a mound of elevation of approximately 1600 feet, appears to be hydrologically impossible without long-term active management. Northward flow would be primarily from the PolyMet east pit and, despite attempted containment in the surficial aquifer, from the Category 1 stockpile. These flowpaths have been overlooked in project evaluations of contaminant transport. The current project contaminant transport modeling, which assumes contaminant flow paths only to the south and south-east, is incomplete because it is based on the incorrect assumption of 1996 era water levels in the taconite pits, even during closure, a water level that is more than 300 feet too high.

Northward flow in the surficial aquifer:

In addition to potential for northward flow of contaminants in the bedrock that is documented in our previous correspondences, including our email of July 21 ("Materials for July 22nd modeling discussion, part 2", attached as Attachment A) and ERM's MathCad modeling, there is evidence that flow may be to the north in the surficial aquifer. In the examples from other taconite pits represented by Figures 2 and 3 of the Barr June 4th memo (attached as Figures 10 and 11), accounting for the compressed x-axis scale, the cross-sections appear to show that the cone of depression caused by taconite pits extends 1.4 to 1.5 miles from the pits in the surficial aquifer. The PolyMet east pit is only 1.2 miles and the Category 1 stockpile is only 0.8 miles from the edge of the final Peter-Mitchel pit (attached as Figure 7). Preliminary MODFLOW modeling of the surficial aquifer shows northward flow of contaminants from the PolyMet east pit in the surficial aquifer. This is the case if model recharge is limited to the 0.75 in/yr used in the PolyMets closure model (PFEIS page 5-27) but also if the model is run with more than 8 in/yr of recharge to the surficial aquifer. The drawdown by the over 300 foot deep

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taconite pits is so great that the surficial aquifer becomes partly dewatered and all baseflow in the upper Partridge ceases.

Importance of understanding groundwater hydrology for prediction of surface water impacts:

Adequate characterization of the groundwater system at a proposed mine site is essential to understanding most of the potential impacts from the project. The amount of water entering the groundwater system, be it precipitation or discharge from the bed of lakes, rivers or mine pits, determines the direction of flow and dilution of contaminants, and dictates points of compliance for both ground and surface waters. The horizontal and vertical conductivity of the soil and bedrock materials determines how the groundwater system responds to stresses and the rate at which the groundwater flows horizontally and vertically. The character of interaction between surface water features and the groundwater system, whether it is loss of water from rivers or wetlands to the groundwater system, or discharge from the groundwater system to the surface water features, determines predicted impacts to surface water features by stresses such as mine dewatering. Estimating water budgets and quantities of water that must be treated requires an adequate understanding of the groundwater system. None of the above effects of a mine project can be predicted accurately if there is not an adequate characterization of the groundwater system. Without an integrated model of the groundwater system, one would be left with only professional judgment to determine the value of the many interrelated parameters that are used for impact prediction. Professional judgment is useful in checking the reasonableness of the predictions from a groundwater model but, by itself, can not adequately integrate the complex site specific information, all pieces of which must fit together like a complex puzzle.

The essential role of groundwater system characterization, characterization that integrates information from the available sources into a coherent model, is demonstrated by the myriad of uses that the project groundwater model has been put to by the applicant during impact evaluation. We have compiled, from the text in the WMDPv13 and the PFEIS, references to the use of the groundwater modeling to predict impacts from the proposed project . Those uses range from contaminant flow direction and gradients (PFEIS page 5-26) to delineation of the Area of Potential Effect for cultural impacts (PFEIS page 4-309 and Figure 4.2.9-5). Project documents include very clear statements about the importance of MODFLOW in formulating impacts, for example the Water Modeling Data Package v13 Section 5.1.2.6 states:

> "Groundwater contours for the unconsolidated deposits and bedrock are the primary source of information used to delineate the flow path areas. The groundwater contours are from the Mine Site MODFLOW model"

The GoldSim contaminant transport modeling in particular uses many outputs from the MODFLOW groundwater modeling (attached as Table 3). These extend far beyond the original purpose of the groundwater model; which was to predict pit inflow, thus making it very clear that a valid model that characterizes site groundwater hydrology is foundational for impact prediction.

The project MODFLOW model was used to characterize the general nature of the groundwater system such as mine site head distribution (e.g. watertable, Large Figure 14 of the WMDPv13, attached as Figure 12), groundwater levels at closure (e.g. Large Figure 30 of Attachment B of WMDPv13, attached as Figure 13) and contaminant flow paths (Large Figures 28 & 29 of the WMDPv13, attached as Figures 3 & 4). In addition, the MODFLOW model was used to supply the numeric input parameters to the GoldSim model that is used for prediction of contaminant flow and contaminant concentrations (WMDPv13, Table 1-1). That table, attached as Table 4, identifies approximately 12 critical GoldSim input parameters that are outputs from the mine site MODFLOW groundwater model. Of those twelve, approximately 6 parameters are related to mine pit inflow; the rest of the 12 parameters relate to the groundwater system across the entire mine site. Those parameters include contaminant flowpath conductivity (K_flowpath), flowpath gradients (I_ops), bedrock porosity (Bedrock_Porosity), recharge (Recharge_min and Recharge_max) and flowpath gradients at closure (I_close). While some of these parameters, such as flowpath conductivity, are secondarily derived from MODFLOW outputs, MODFLOW is an input to calculation of the GoldSim parameter, as documented in WMDP(v13) Section 5.2.3.3.

It is clear that without the conceptual (flow directions etc.) and numeric (gradient, conductivity etc.) outputs from the MODFLOW model, the GoldSim model could not be run. Because of the dependence of the GoldSim modeling of contaminant transport on MODFLOW model outputs, it is essential that the MODFLOW outputs be valid. Because the MODFLOW model was incorrectly calibrated to baseflow from 1979-88 and bounded with taconite pit water levels from 1996 it is very unlikely that the MODFLOW outputs are correct. Not only was the calibration model incorrectly bounded but the predictive runs use the same abnormally high P-M pit water levels. In particular the predictive runs for long-term closure (MODFLOW run "SS_west_fill_Sept2014_1585ec1595" resulting in Large Figures 29 and 30, WMDPv13 and PFEIS Figure 5.2.2-7) use the 1996 taconite pit water levels that are over 300 feet higher than the expected closure water levels.

Need for a consistent conceptual model of site hydrology:

There are two conflicting conceptual models presented in the draft northward flowpath memo: 1) that surface water features are not well connected to the bedrock, e.g. the Argo & Iron Lakes examples, and a multitude of previous EIS documents arguing for separated surficial and bedrock aquifers and against wetland impacts (see email of July 29, 2015, attached as Attachment C); and 2) that surface water features are well connected to the bedrock aquifer and that the 100 Mile Swamp (a wetland) can supply at least 8 inches/year of leakage. These two arguments would seem to be mutually exclusive. Both arguments can not be used simultaneously to support the concept of a groundwater mound between the PolyMet and Peter-Mitchel projects. A third argument has been hinted at during meetings; that the bedrock between PolyMet and the P-M pits is of such low conductivity that the cone of depression from the mine pits does not extend any significant distance from the pits. This argument is not supported by the site-specific conductivity data collected on the Virginia Formation or the documented conductivity of the Biwabik Iron Formation (see PFEIS tables 4.2.2-5 and 5.2.2-7).

A coherent conceptual model needs to be articulated, either one in which surface water features are poorly connected to the bedrock aquifer and are therefore, unaffected by pit dewatering, or one in which surface water features are well connected to the bedrock aquifer and can provide leakage to support a groundwater mound between the PolyMet and Peter-Mitchel pits. If the first model is accepted then wetlands and the upper Partridge River may be little affected by pit dewatering but dewatering of the Peter-Mitchel pits causes a bedrock northward flowpath to develop at closure. If the second conceptual model is accepted then a bedrock groundwater mound develops, but wetlands and the upper Partridge River are severely impacted by PolyMet and Peter-Mitchel pit dewatering.

"Adaptive management" as a substitute for understanding the site and predicting impacts:

Given the uncertainty that the co-leads feel there is in characterization of contaminant flowpath direction, the draft co-lead memo of June 22 proposes several mitigations that attempt to prevent northward flow of contaminants. The feasibility of any of those measures has not been evaluated. Even with the minimal information presented in the memo, several obstacles to successful mitigation of a northward flowpath are evident: 1) The thickness of the low conductivity surficial deposits between the PolyMet site and the P-M pits, approximately 50 feet thick according to Minnesota Geological Survey 2005 publication M158, makes the practicality of an infiltration trench questionable; 2) Lowering of water levels in the the PolyMet pits would expose reactive Virginia Formation rock to air and water, creating acid generation and dewatering surrounding wetlands; 3) Groundwater injection or extraction wells may be a feasible, but costly, mechanism to block northward flow but, as noted in the memo, would require perpetual operation, care and replacement.

In addition to the proposed adaptive management appearing to be impractical, substituting 'adaptive management" for understanding of the hydrologic system is contrary to the NEPA concept of site characterization and impact prediction. NEPA is a forward looking process with the goal of anticipating and describing impacts so that measures can be taken to avoid or minimize those impacts. A northward flowpath for contaminants is indicated by both MODFLOW and MathCad. The character of the hydrology between the PolyMet and P-M projects needs to be described correctly so that impacts of that northward flowpath can be evaluated and the feasibility of mitigation measures can be determined.

In summary:

- The project mine site groundwater flow model (MODFLOW) was calibrated with multiple conditions that did not exist simultaneously, i.e. boundary conditions in the form of taconite pit water levels from 1996 and river baseflows from 1979-88. This means that the mine site model is not correctly configured and, therefore, unlikely to generate accurate predictions.

- The project model was configured and used by the applicant as a basis for contaminant transport predictions at closure. As configured, it predicts that contaminants would flow from the PolyMet site south to the Partridge River at project closure. However, if the model is configured with correct closure boundary conditions in the form of taconite pit water levels at their closure level of 396 meters (1300 feet) or the very long-term level of 457 meters (1500 feet), contaminants are predicted to flow to the north toward the P-M pits. This contaminant flow direction (to the P-M pits) is opposite the direction assumed for the current project contaminant transport modeling. The project contaminant modeling is incomplete because it does not evaluate northward flow of contaminants from either the PolyMet pits or the Category 1 stockpile.

- The conceptual model used for the basis of many of the conclusions in project reports and in the PFEIS text is that the taconite pits have little influence on the surrounding aquifer, regardless of whether they are full of water or pumped dry and that the surface water features are not hydraulically connected to the bedrock aquifer. However, the mine site MODFLOW model, which incorporates historical and site-specific conductivity data on the bedrock formations and is used by the applicant to predict closure conditions, indicates that the taconite pits have a profound impact on the surrounding aquifer. This is because the cone of depression caused by taconite pit dewatering extends well into the surrounding bedrock. Impact on the aquifer makes sense because of the relatively high horizontal conductivity of the bedrock in which the taconite pits sit.

-The current concept, articulated in the draft co-lead memo on a northward flowpath and the supporting MathCad modeling, appears to recognize the documented horizontal conductivities of the bedrock formations, yet seems to propose both the isolation of surface water features and the transmission of large quantities of water from surface water features to the bedrock. Both

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isolation and transmission are not simultaneously possible. A consistent conceptual model must be presented.

-Pit dewatering may induce significant quantities of water from the surficial aquifer into the bedrock. Although this would likely cause substantial wetland & stream impacts, natural formation of a groundwater mound in the bedrock, adequate to prevent northward flow, is impossible given the conductivities documented in the project materials.

The mine site groundwater model needs to be reconfigured to contain realistic water levels in the P-M taconite pits, both for a "current conditions" model and a "closure conditions" model, not the 1996 water levels that were unusually high. The predictive modeling for the post closure period must use the correct closure water elevations for the P-M pits which are 300 feet lower than the unusually high 1996 levels. Groundwater modeling with MODFLOW, with correct P-M pit closure water levels of 396 meters, and MathCad modeling, both indicate that at closure contaminants are likely to flow north in addition to the southward direction currently assumed by project reports. Evaluation of contaminate flow to the north must be conducted and impacts predicted. Sensitivity analysis and adaptive management can not be substitutes for consistent and rational characterization of site hydrology.

Sincerely,

John Coleman

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